Naval Fuels & Lubricants
Cross Functional Team
Test Report

Impact of 200 ppm HiTEC® 4898C Lubricity Improver Additive (LIA) on F-76 Fuel Coalescence

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LIST OF ACRONYMS/ABBREVIATIONS

ASTM ..... American Society for Testing and Materials

F-76 ..... USN F-76 Grade Diesel Fuel

FLC ..... Fleet Logistics Center

IAW ..... in accordance with

LIA ..... lubricity improver additive

NCT ..... Navy Coalescence Test

PPM ..... parts per million

DEFINITIONS

Coalescence..... the ability to shed water from fuel

Dissolved Water.....water that is in solution with the fuel i.e. at or below the saturation point

Element .....a separation device comprised of a filter coalescer and separator

Free Water .....water in a multi-fluid stream which is above the fluid's saturation point (not dissolved water)

Saturation point.....the total water concentration at which all water present in the fuel is dissolved in the fuel and the further addition of water will result in the presence of free water. The saturation point is heavily dependent on the chemical composition of the fuel and temperature.

Turnover .....time required to flow the entire volume of fluid in a container, also known as residence time (volume of fuel ÷ volumetric flow rate)

EXECUTIVE SUMMARY

As the Navy transitions to the use of low-sulfur diesel fuels, the inherent lubricity of F-76 will decrease due to the removal of sulfur containing compounds known to have good natural lubricity. As specified in MIL-DTL-16884N, F-76 must produce a wear scar diameter less than 460 µm when tested in accordance with (IAW) ASTM D6079 or ASTM D7688. In order to meet this requirement the addition of lubricity improver additives (LIA) may be necessary. Prior to approving a LIA for use in F-76, the LIA must show no detrimental effects on fuel properties.

HiTEC® 4898C is a synthetic neutral LIA produced by Afton Chemical Corporation. HiTEC® 4898C was designed for use in low sulfur diesel fuels and as such considered a viable F-76 LIA option. However, F-76 containing 200 parts per million by volume (ppm) HiTEC® 4898C displayed a poor ability to separate from water when tested IAW ASTM D1401 and ASTM D7261. To further examine the effects of 200 ppm HiTEC® 4898C on water separability, a Navy Coalescence Test (NCT) was completed. The NCT is a fit-for-purpose test which uses a specially manufactured scaled down filter/coalescer cartridge to simulate the performance of a full scale filter/coalescer system. This test is designed to predict the performance of new additives and fuels on filter/coalescer systems currently in use by the fleet.

After 80 hours of testing it was concluded that F-76 containing 200 ppm HiTEC® 4898C meets the acceptable performance criteria. However, due to the fuel's poor demulsification results a risk assessment is needed prior to approving the use of HiTEC®4898C at a concentration of 200 ppm.

Impact of 200 ppm HiTEC® 4898C Lubricity Improver Additive (LIA) on F-76 Fuel Coalescence

1.0 BACKGROUND

Sufficient lubricity of F-76 is essential to the prevention of premature degradation of pumps and other fuel-lubricated components. As the Navy transitions to low-sulfur diesel fuels, the inherent lubricity of F-76 will decrease due to the removal of sulfur containing compounds known to have good natural lubricity. As specified in MIL-DTL-16884N, F-76 must produce a wear scar diameter less than 460 µm when tested in accordance with (IAW) ASTM D6079 or ASTM D7688. In order to meet this requirement the addition of lubricity improver additives (LIA) may be necessary. Prior to approving a LIA for use in F-76, the LIA must show no detrimental effects on fuel properties.

HiTEC® 4898C is a synthetic neutral LIA produced by Afton Chemical Corporation. HiTEC® 4898C was designed for use in low sulfur diesel fuels and as such considered a viable F-76 LIA option. Afton Chemical Corporation suggests a dosage concentration of 100 ppm in low-sulfur diesel fuels. For this test, a dosage rate two times the suggested dosage rate was used.

Laboratory tests have shown F-76 containing 200 parts per million by volume (ppm) HiTEC® 4898C inadequately separated from water. The fuel failed to separate from water when tested IAW ASTM D1401 within 10 minutes as required by MIL-DTL-16884N (actual time= 19 mins). The fuel also failed to meet the diesel microseparometer fit-for-purpose requirement of 90 (actual result= 51) when tested IAW ASTM D7261. Based on these results a NCT was completed to test whether HiTEC® 4898C has an adverse effect on filter coalescer performance.

2.0 OBJECTIVE

The objective of this test was to determine the effects of HiTEC® 4898C LIA at a concentration of 200 ppm on the coalescence properties of F-76 by comparing free water levels upstream and downstream of a scaled-down filter coalescer and separator element.

3.0 APPROACH

3.1 Test Overview

Testing spanned from 6/19/13 to 7/9/13 and was conducted IAW the NCT Standard Work Package (SWP44FL-003). The test is comprised of saturating dry fuel with water (via wet N_2 sparging), injecting 250 ± 50 ppm of free water upstream of the filter coalescer and separator element, and removing the water via the element. Every hour the total water concentration in the fuel is measured at each of these three locations per ASTM D6304. Three samples from the inlet and outlet of the capsule and one sample of water saturated fuel are measured each hour. By measuring and graphing the results of the water levels at these three locations, the effects on

coalescence can be determined. When coalescence is unaffected, the water levels in the saturated fuel and at the outlet of the element are close in value and give consistent results. When coalescence is compromised, the water levels at the inlet and outlet of the element are closer. Differential pressure across the coalescer is also recorded to ensure the differential pressure does not exceed 15 psi at which point filter coalescer and separator performance is compromised. The standard test duration is 80 hours. A flow schematic for the NCT rig is shown in Figure 1.

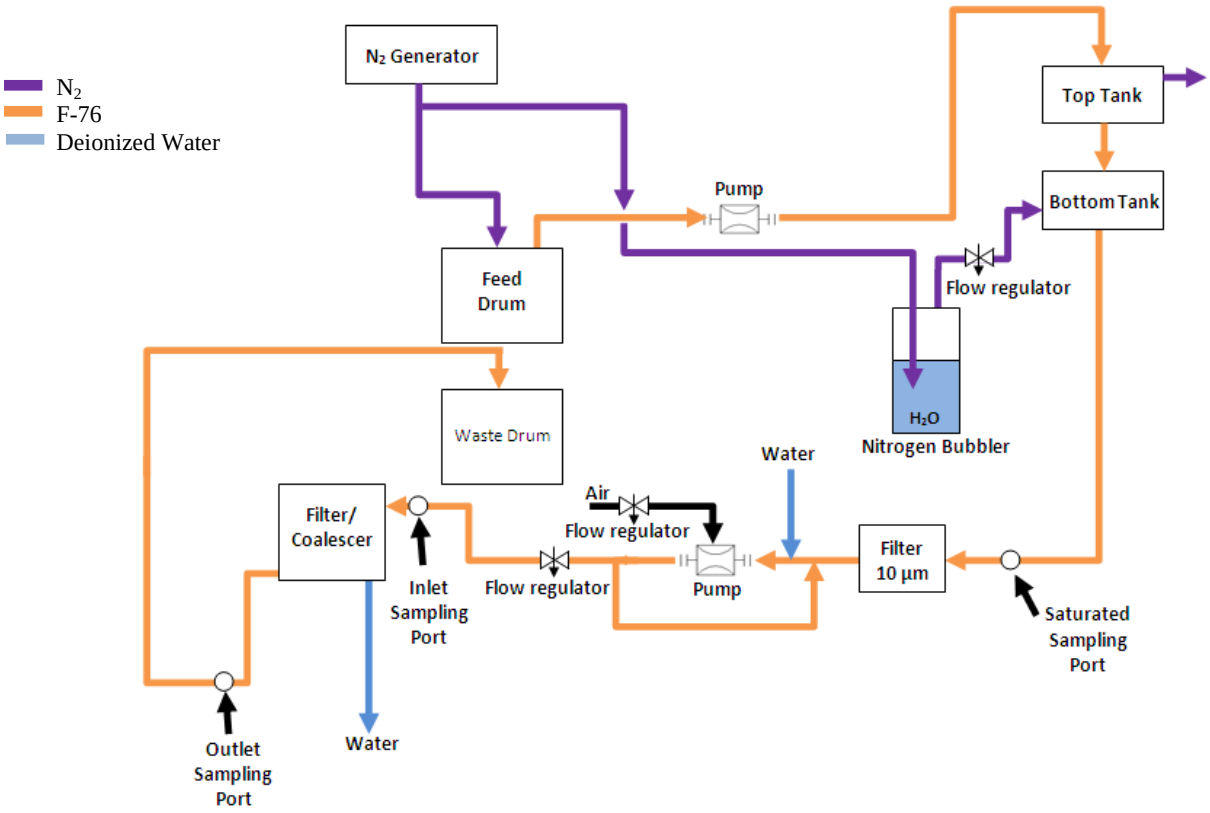

Figure 1: NCT Flow Schematic

3.2 Test Fuel

The base fuel (F-76) was acquired from Fleet Logistics Center (FLC) Puget Sound. Laboratory tests were completed at NAS Patuxent River's Naval Fuels Laboratory to ensure the test fuel met all physical and chemical requirements specified in MIL-DTL-16884N except for sulfur content (F-76 procured to earlier version of MIL-DTL-16884). The elevated levels of sulfur pose no effect on the objective of this test as the base fuel alone exhibits satisfactory water coalescence. To prevent sediment from clogging the lines of the NCT rig, the base fuel was recirculated through a series of 0.5 micron (nominal) filters and coalescers until the particulate content and total water concentration of the test fuel was 0.01 mg/L and 56.4 ppm, respectively. After the base fuel was filtered, HiTEC® 4898C was added at a concentration of 200 ppm. The F-76 and HiTEC® 4898C solution was recirculated for 20 turnovers to ensure even and complete dissolution of the LIA. After adding HiTEC® 4898C, the base fuel produced a wear scar

diameter of 400 µm when tested IAW ASTM D6079. Prior to adding HiTEC® 4898C, the base fuel produced a wear scar diameter of 430 µm.

3.3 Acceptance Criteria

In order to successfully pass the NCT, the difference between the total water concentration of the saturated fuel and the fuel leaving the test element must be less than 100 ppm. If this criterion is not met for four consecutive hours, the test will be reported as a failure. The 100 ppm limit has been chosen because it allows for variations in the fuel sample, as well as system disturbances such as excess water injection and incomplete saturation due to fluctuations in nitrogen pressure. The differential pressure across the filter/coalescer shall not exceed 15 psi at any point during the test. If the differential pressure exceeds 15 psi the fuel fails the NCT.

4.0 DISCUSSION

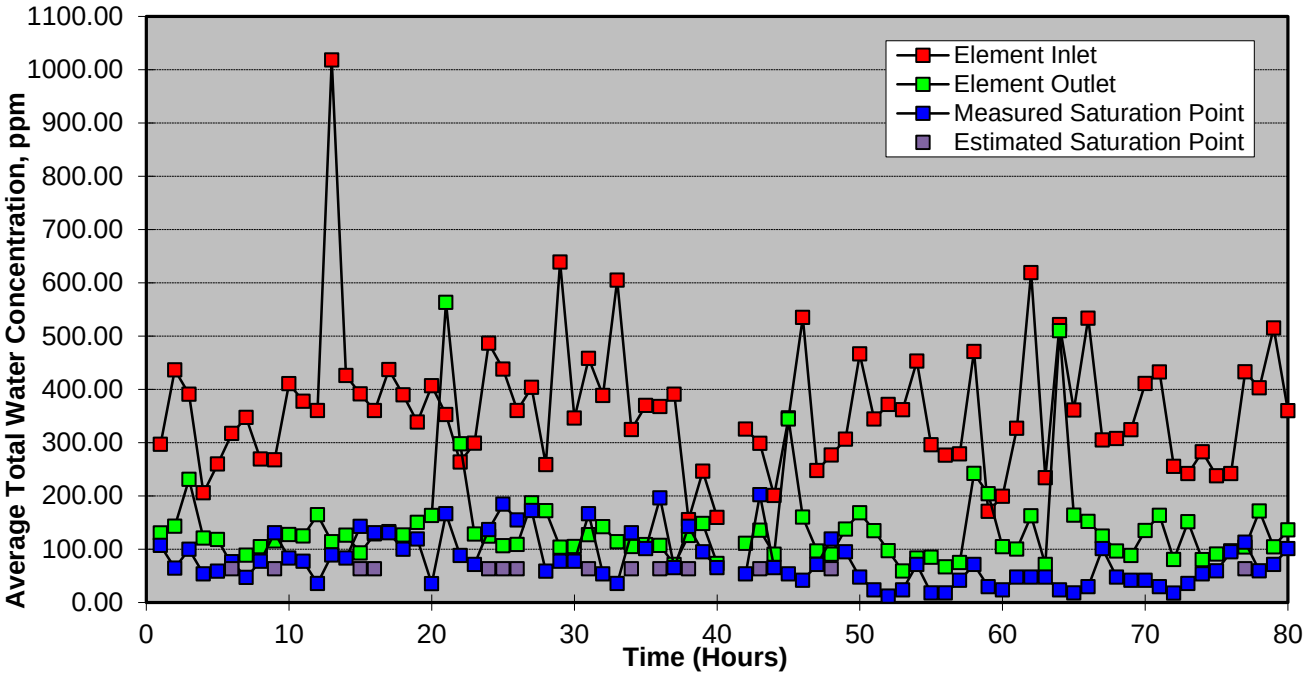

Figure 2: Average Total Water Concentration of F-76 with 200 ppm HiTEC® 4898C: Inlet, Outlet, and Saturated Water Concentrations

The average saturated, inlet and outlet total water concentrations can be found in Figures 2 and 3. Figure 3 excludes the inlet readings to better illustrate the differences between the saturated and outlet readings. Times when the outlet water concentrations are below the saturation concentration are indicative of periods of excessive water saturation since filter coalescers are only able to remove free water. For the 14 test hours this occurred, it would be inappropriate to compare the difference between the saturation and outlet total water concentrations since the measured saturation values are not true representations of the saturated water levels. Since the fuel temperature remained between 68°F and 71°F throughout the

evaluation period, the average water saturation concentration, 63±34 ppm (excluding the 14 occurrences of oversaturation), is a reasonable estimate of the water saturation concentration.

At test hour 41, there was a power outage at the test facility and measurements could not be taken and are therefore omitted. At test hour 13, a sample containing 1,870 ppm of water was collected at the inlet to the filter/coalescer capsule resulting in an average inlet concentration of 1,018 ppm. This was most likely due to inadequate mixing in the piping at the time of sampling as the two other inlet readings (643 ppm and 542 ppm) taken at that time were more consistent with the other test points. Therefore the results from test hour 13 are included in this analysis.

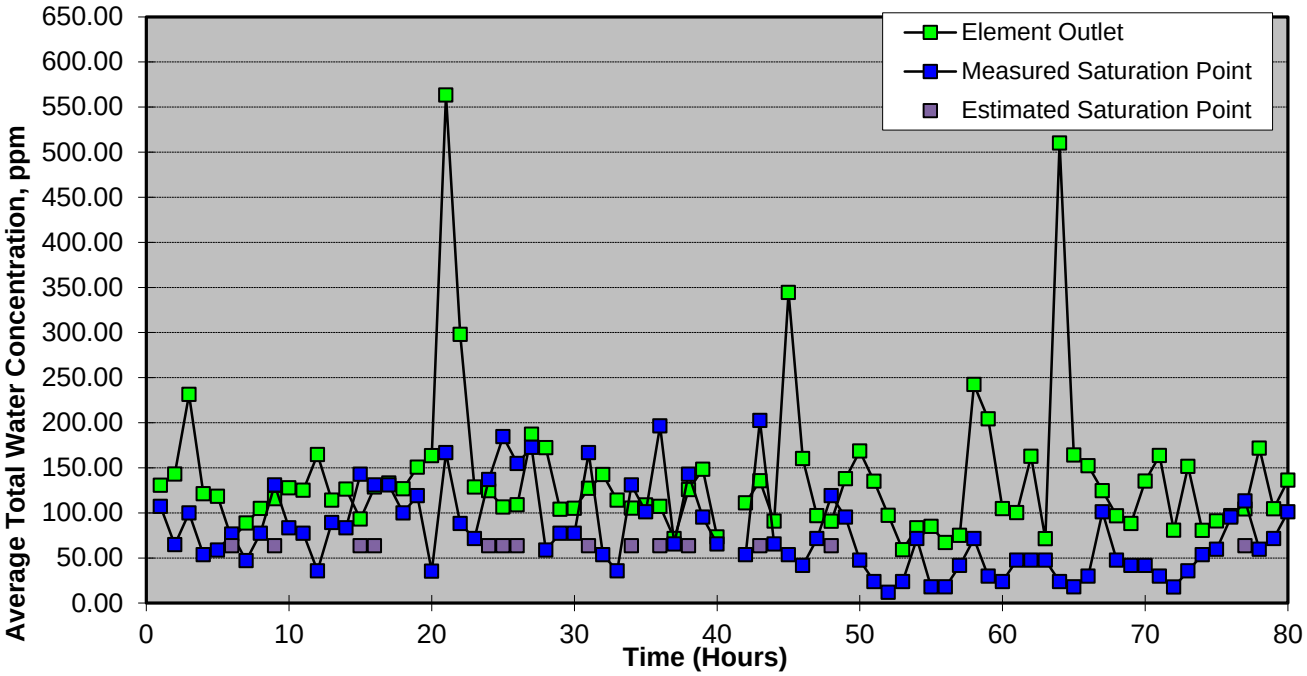

Figure 3: Average Total Water Concentration of F-76 with 200 ppm HiTEC® 4898C: Outlet and Saturated Water Concentrations

A comparison of the average amount of free water injected and coalesced/removed can be seen in Figure 4. At test hours 21, 22, and 59, more water was measured at the outlet of the filter separator housing than the inlet of the housing (shown as negative values in Figure 4). The average injected water concentration was 299±128 ppm (inlet total water concentration – saturated total water concentration), higher than the target minimum injection rate of 200 ppm. The average outlet water concentration was 138±80 ppm. The free water concentration (outlet total water concentration – saturated total water concentration) in the test fuel after passing through the test element can be seen in Figure 5. An estimated free water concentration was calculated for the 14 occurrences of oversaturation by taking the difference between the measured outlet concentrations and the average water saturation concentration.

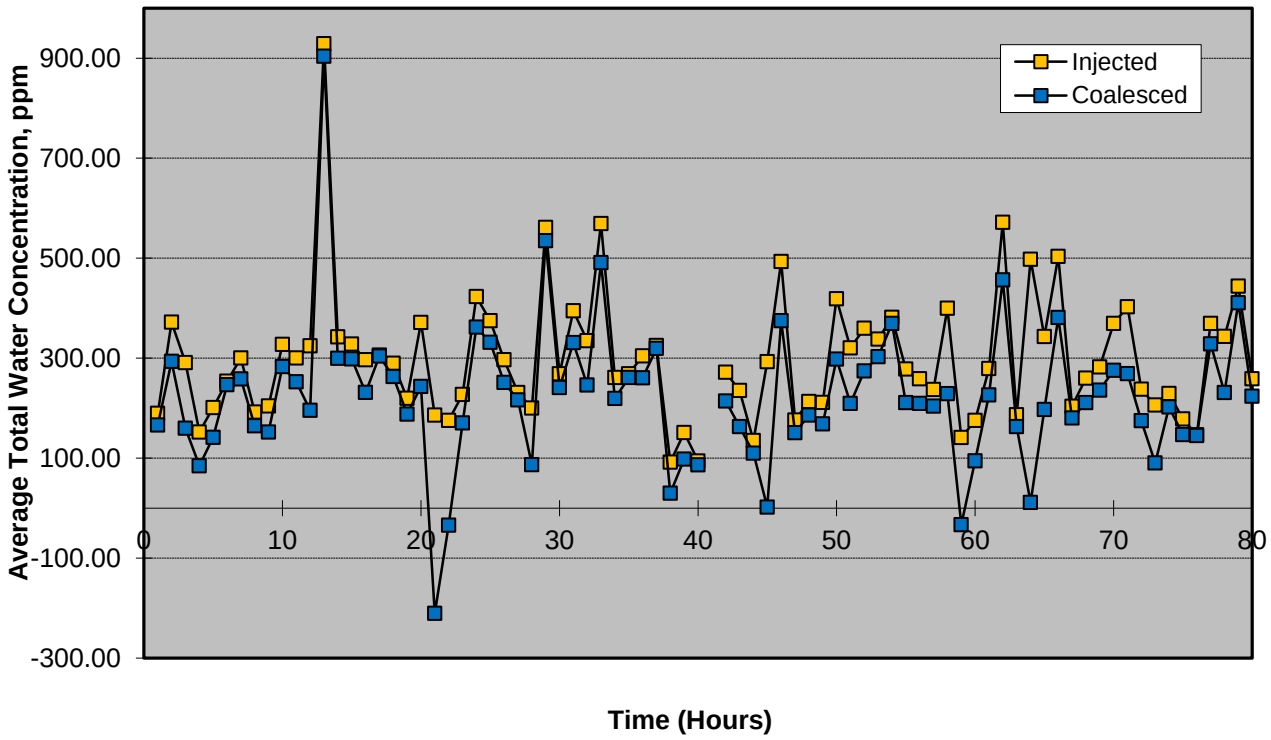

Figure 4: Injected and Coalesced Free Water

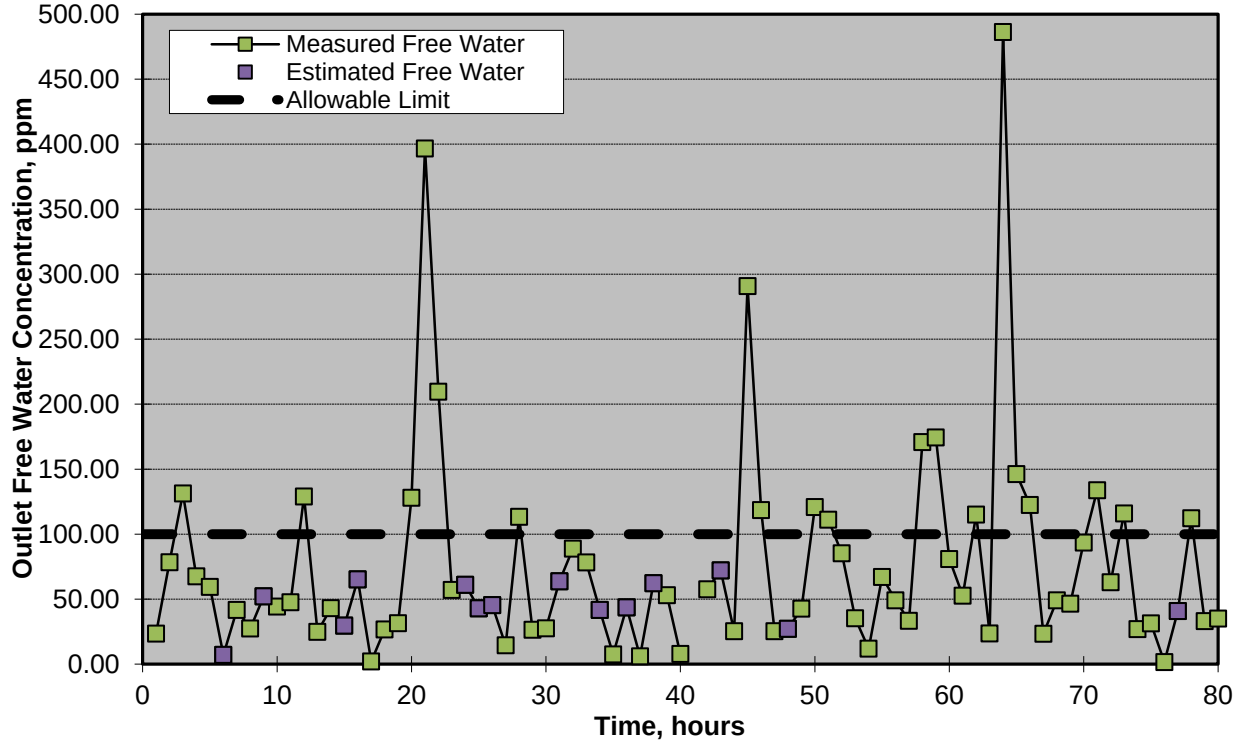

Figure 5: Free Water Concentration at Outlet of Test Element

Figure 5 shows that all but 19 of the test hours fell within the 100 ppm limit and that an outlet free water concentration in excess of 100 ppm didn't occur for more than three consecutive hours. The average difference between the outlet and saturated total water concentrations—including the 14 estimated differences— was 74±79 ppm. At no point during the test did the differential pressure across the filter/coalescer and separator capsule go above 5 psig, indicating that this fuel does not accelerate the clogging of filter/coalescers. F-76 additized with 200 ppm HiTEC® 4898C meets the acceptable coalescence performance criteria and does not have any adverse effect on water coalescence.

5.0 CONCLUSIONS

The F-76 with 200 ppm HiTEC® 4898C test fuel met all of the NCT requirements satisfactorily. Based on this analysis, F-76 with 200 ppm HiTEC® 4898C has no negative effects on water coalescence.

6.0 RECOMMENDATIONS

It is recommended further wear scar and water separability testing be completed at the suggested dosage rate of 100 ppm HiTEC® 4898C. A risk assessment is needed prior to approving the use of HiTEC® 4898C in F-76 at a concentration of 200 ppm due to the fuel's inability to successfully demulsify within 10 minutes as required by MIL-DTL-16884N.

7.0 REFERENCES

SWP44FL-003 Navy Fuels and Lubricants CFT Navy Coalescence Tester (NCT)

Appendix A

Table A-1. Test Data

Run Time (test hour)	avg. inlet (ppm)	avg. outlet (ppm)	avg. tank (ppm)	ΔP (psi)
1	297	131	107	0
2	437	143	65	0
3	391	231	100	0
4	206	121	54	0
5	260	118	59	0
6	317	71	76	0
7	347	89	47	0
8	269	105	77	0
9	268	116	131	0
10	411	128	83	0
11	378	125	77	0
12	360	165	36	0
13	1018	114	89	0
14	426	126	83	0
15	391	93	143	0
16	360	129	131	0
17	437	133	131	0
18	390	127	100	0
19	339	151	119	0
20	407	163	35	0
21	353	563	167	0
22	264	298	88	1
23	299	129	71	1
24	487	125	137	1
25	438	106	185	1
26	360	109	155	1
27	404	187	173	1
28	259	172	59	1
29	639	104	77	1
30	346	105	77	1
31	458	127	167	1
32	388	142	54	1
33	605	114	36	1
34	325	105	131	1
35	370	109	101	1
36	368	107	196	1
37	391	71	65	1
38	155	126	143	1
39	246	148	95	1
40	160	73	65	1

Table A-1. Test Data (Continued)

Run Time (test hour)	avg. inlet (ppm)	avg. outlet (ppm)	avg. tank (ppm)	ΔP (psi)
41				
42	325	111	54	1
43	299	136	202	1
44	201	91	65	1
45	346	344	54	1
46	535	160	42	1
47	248	97	71	1
48	277	91	119	1
49	306	138	95	1
50	466	169	48	1
51	344	135	24	1
52	372	97	12	1
53	362	59	24	1
54	453	83	71	1
55	296	85	18	1
56	276	67	18	1
57	279	75	42	1
58	471	242	71	1
59	171	204	30	1
60	199	105	24	1
61	327	100	48	1
62	619	163	48	1
63	234	71	48	1
64	522	510	24	1
65	361	164	18	1
66	533	152	30	1
67	305	125	101	1
68	308	97	48	1
69	324	88	42	1
70	411	135	42	1
71	433	164	30	1
72	255	81	18	1
73	242	152	36	5
74	283	81	54	5
75	238	91	60	5
76	242	97	95	5
77	433	104	113	5
78	403	172	60	5
79	515	104	71	5

**Results from test hours 41 are omitted due to an electrical power failure*

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14. ABSTRACT

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